Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

MATHEMATICS

ON THE GEOMETRICAL STRUCTURE OF THE SYMMETRIC TRANSFORMATION IN HILBERT'S SPACE

By M. M. GREENBLUM

(Communicated by I. M. Vinogradow, Member of the Academy, 7. VIII. 1936)

Let $\mathfrak{H}$ be the abstract complex Hilbert's space and $g = Hf$ the closed symmetric transformation defined in the linear manifold D everywhere dense in $\mathfrak{H}$.

By using the simple properties of the closed linear manifold formed of the elements $Hf + if$ where $f \in D$ we can prove the theorem:

Theorem I. If D is the domain of the symmetric transformation H, there exists in D a sequence of the elements $x_1, x_2, \ldots$ with the following properties:

1) Each element $f \in D$ may be represented, and at the same time only in the unique manner, as $f = \sum_1^\infty c_i x_i$, where $\sum_1^\infty |c_i|^2 < \infty$, and, conversely, if $\sum_1^\infty |c_i|^2 < \infty$, the series $\sum_1^\infty c_i x_i$ converge and the element represented by its sum belongs to D.

2) Sequence $\{y_i = Hx_i\}$ in the range of transformation H plays a part similar to that played by sequence $\{x_i\}$ in D; when $f = \sum_1^\infty c_i x_i$, then $Hf = \sum_1^\infty c_i y_i$. In a general case the representation of Hf in the form $\sum_1^\infty c_i y_i$ is possible in different ways.

3) Elements $\{x_k\}$ and $\{y_k\}$ satisfy the following conditions:

$$\| y_k \|^2 + \| x_k \|^2 = 1 \qquad (k = 1, 2, \ldots),$$
$$(y_p, y_q) + (x_p, x_q) = 0 \qquad (p \neq q),$$
$$(x_p, y_q) = (y_p, x_q) \qquad (p, q = 1, 2, \ldots).$$

Definition. Sequence $\{x_i\}$ satisfying the conditions of theorem I is called the determining sequence of the transformation H.

Theorem II. If $f = \sum_1^\infty c_i' x_i'$ and $f = \sum_1^\infty c_i'' x_i''$ are the representations of the element $f \in D$ with regard to two different determining sequences $\{x_i'\}$ and $\{x_i''\}$, then $\sum_1^\infty |c_i'|^2 = \sum_1^\infty |c_i''|^2$.

Note 1. It would be of great interest to estabilish whether any linear manifold everywhere dense in $\mathfrak{H}$ in which there exists a basis satisfying the conditions of point 1) in theorem I is the domain of existence of some closed symmetric transformation *.

Behaviour of H in the neighbourhood of the element. Let $\{f_n\}$ be the sequence of elements in D converging to $f_0 \in D$ and let

$$f_n = \sum_1^\infty c_i^{(n)} x_i, \quad f_0 = \sum_1^\infty c_i^{(0)} x_i,$$

where $\{x_i\}$ is the determining sequence.

Theorem III. 1) If $\sum_1^\infty |c_i^{(m)} - c_i^{(n)}|^2 \to 0$, when $n, m \to \infty$, then $Hf_0 = \lim Hf_n$ when $n \to \infty$, and besides $\sum_{i=1}^\infty |c_i^{(n)} - c_i^{(0)}|^2 \to 0$, when $n \to \infty$.

2) If $Hf_0 = \lim Hf_n$, when $n \to \infty$, then $\sum_{i=1}^\infty |c_i^{(m)} - c_i^{(n)}|^2 \to 0$, when $n, m \to \infty$.

Corollary 1. If $\sum_{i=1}^\infty |c_i^{(m)} - c_i^{(n)}|^2$ does not tend to zero when $n, m \to \infty$, the sequence Hf_n diverges.

Theorem IV. If $\sum_{i=1}^\infty |c_i^{(n)}|^2 \to \infty$, when $n \to \infty$, then $\|Hf_n\| \to \infty$, and, conversely, if $\|Hf_n\| \to \infty$ then $\sum_{i=1}^\infty |c_i^{(n)}|^2 \to \infty$.

Corollary 2. Sequences $\{f_i\}$ of the elements in D converging to element $f_0 \in D$ are divided into two classes. The first class consists of sequences, for which $\sum_{i=1}^\infty |c_i^{(m)} - c_i^{(n)}|^2$ tends to zero when $n, m \to \infty$.

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* The following general problem is of great interest: to study the conditions under which the linear manifold everywhere dense in $\mathfrak{H}$ but not coinciding with $\mathfrak{H}$ has a basis satisfying point 1) in theorem I.

The second class consists of sequences for which $\sum_{i=1}^{\infty} | c_i^{(m)} - c_i^{(n)} |^2$ does not tend to zero when $n,\ m \to \infty$.

If H is the discontinuous transformation, not one of these classes is empty. In the second class there exists already the sequences for which $\sum_{i=1}^{\infty} | c_i^{(n)} |^2 \to \infty$, when $n \to \infty$.

If H is continuous, the second class is empty.

Matrix of transformation

Let $\{x_i\}$ be the determining sequence and $y_i = Hx_i$. Let further $\{\varphi_i\}$ be the complete ortonormal system in $\mathfrak{H}$. We introduce the notations: $a_k^{(p)} = (x_p,\ \varphi_k)$ and $b_k^{(p)} = (y_p,\ \varphi_k)$.

Theorem V. Series $\sum_{p=1}^{\infty} | a_k^{(p)} |^2$ and $\sum_{p=1}^{\infty} | b_k^{(p)} |^2$ converge, as well as series $\sum_{k=1}^{\infty} \left| \sum_{p=1}^{\infty} c_p a_k^{(p)} \right|^2$ and $\sum_{k=1}^{\infty} \left| \sum_{p=1}^{\infty} c_p b_k^{(p)} \right|^2$, whatever may be the sequence $\{c_i\}$ satisfying the condition $\sum_{1}^{\infty} | c_i |^2 < \infty$.

Theorem VI. If f is an element in D, then

$$(f,\ \varphi_k) = c_1 a_k^{(1)} + c_2 a_k^{(2)} + \ldots + c_n a_k^{(n)} + \ldots, \qquad (1)$$

$$(Hf,\ \varphi_k) = c_1 b_k^{(1)} + c_2 b_k^{(2)} + \ldots + c_n b_k^{(n)} + \ldots, \qquad (2)$$

where c_i are the components of f by the determining sequence. Conversely, if $\sum_{1}^{\infty} | c_i |^2 < \infty$, then the right parts of (1) and (2) give the values of the components with regard to φ_k of the element $f = \sum_{i=1}^{\infty} c_i x_i$ and Hf respectively.

Note 2. In comparison with the usually considered matrices equivalent to transformation H the matrix constructed here has the advantage that for this matrix, with the exhaustion of all sequences $\{c_i\}$ satisfying the condition $\sum_{1}^{\infty} | c_i |^2 < \infty$, we obtain all the elements f and Hf and no foreign elements. Further we shall see that this property leads to conditions of a very simple and finished form characteristic of the point as well as residual spectra.

Transformation $Hf - \lambda f = H_\lambda f$.

Let be D_λ the range of transformation H_λ.

Theorem VII. Each element of D_λ may be represented in the form $\sum_{1}^{\infty} c_i (y_i - \lambda x_i)$ where $\sum_{1}^{\infty} | c_i |^2 < \infty$ and, conversely, if $\sum_{1}^{\infty} | c_i |^2 < \infty$, the

series $\sum_1^\infty c_i (y_i - \lambda x_i)$ converge and the element represented by its sum belongs to D_λ. If λ does not belong to the point spectrum of H, i. e., if transformation H_λ has the inverse, this representation is unique.

Theorem VIII. In order that λ should belong to the point spectrum, it is necessary and sufficient for the system of linear equations:

$$(b_k^{(1)} - \lambda a_k^{(1)})\, c_1 + (b_k^{(2)} = \lambda a_k^{(2)})\, c_2 + \ldots = 0 \qquad (k = 1, 2, \ldots), \qquad \text{(P)}$$

to have the solution $\{c_i\}$ for which $\sum |c_i|^2 < \infty$.

Theorem IX. In order that λ should belong to the residual spectrum of H, it is necessary for the system of linear equations:

$$(b_1^{(i)} - \lambda a_1^{(i)})\, c_1 + (b_2^{(i)} - \lambda a_2^{(i)})\, c_2 + \ldots = 0 \qquad (i = 1, 2, \ldots), \qquad \text{(R)}$$

to have the solution $\{c_i\}$ satisfying the condition $\sum_{i=1}^\infty |c_i|^2 < \infty$; conversely, if for a given λ there exists a solution of the system (R) for which $\sum_1^\infty |c_i|^2 < \infty$, then λ is either the element of the residual spectrum or such an element of the point spectrum for which the manifold $\sum_1^\infty c_i (y_i - \lambda x_i)$, where $\sum_1^\infty |c_i|^2 < \infty$, is not everywhere dense in $\mathfrak{H}$.

The elements of the matrices of the systems (P) and (R) satisfy the conditions:

1. Series $\sum_{i=1}^\infty |a_i^{(k)}|^2, \sum_{i=1}^\infty |b_i^{(k)}|^2; \sum_{k=1}^\infty |a_i^{(k)}|^2, \sum_{k=1}^\infty |b_i^{(k)}|^2$ converge.

2. Series $\sum_{k=1}^\infty \left| \sum_{i=1}^\infty c_i a_k^{(i)} \right|^2, \sum_{k=1}^\infty \left| \sum_{i=1}^\infty c_i\, b_k^{(i)} \right|^2$ converge for all sequences $\{c_i\}$ satisfying the condition $\sum_1^\infty |c_i|^2 < \infty$.

3. a) $\sum_{k=1}^\infty |b_k^{(p)}|^2 + \sum_{k=1}^\infty |a_k^{(p)}|^2 = 1 \qquad (p = 1, 2 \ldots)$;

   b) $\sum_{k=1}^\infty (b_k^{(p)}\, \overline{b_k^{(q)}} + a_k^{(p)}\, \overline{a_k^{(q)}}) = 0 \quad (p \neq q)$;

   c) $\sum_{k=1}^\infty (b_k^{(p)}\, \overline{a_k^{(q)}} - a_k^{(p)}\, \overline{b_k^{(q)}}) = 0 \quad (p, q = 1, 2, \ldots)$.

In the nearest future I shall once more return to the problems treated in the present paper.

State University,
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Received
7. VIII. 1936.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

PHYSICS

ON THE SLOWING DOWN OF NEUTRONS BY THE NUCLEI OF HEAVY ELEMENTS

By P. I. LUKIRSKY, Corresponding Member of the Academy, and T. CAREVA

It is well known that some nuclear reactions with neutrons take place with greater intensity, when these neutrons have passed through considerable thicknesses of a hydrogen-containing substance.

The collisions of the neutrons with the protons of hydrogen bring about the slowing down of the neutrons to thermal velocities, which is proved by the existence of the temperature effect ([1,2]) and by direct experiments with the mechanical velocity selector ([3]). The slowing down due to collisions between neutrons and protons seems to be the result of elastic collisions.

As the masses of these particles are approximately equal, the energy of the neutron is on the average doubly reduced by every collision. We cannot expect to obtain a considerable decrease of the neutron velocities by elastic collisions of the neutrons with the heavy nuclei. However, the experiments of Wertenstein ([4]), Ehrenberg ([5]), Rotblat and Zyw ([6]) show that, by surrounding the neutron source with different substances containing only heavy nuclei, it is possible to obtain an increase of the nuclear reaction intensity in exactly those cases when such an increase is observed during the slowing down of neutrons by hydrogen-containing substances (paraffin).

An increase of the silver and iodine activity is observed when surrounding the neutron source even with such substances as lead and gold, which possess very heavy nuclei. It is obvious that in this case the change of the neutron velocity by elastic collisions would be quite insignificant.

It is to be supposed that during interactions with heavy nuclei, not the elastic collisions, but some other mechanism leads to the formation of slow neutrons.

If during the penetration through a substance possessing heavy neuclei we obtain very slow neutrons with velocities approaching the thermal velocities, this may be shown by the temperature effect. The following experiment has been made to this end. An ampulla, containing 300 millicurie of radon with beryllium powder was placed in the centre of a leaden sphere 7.4 cm in diameter. This sphere was covered with a thin spherical layer of paraffin. A silver target whose radioactivity was studied was placed outside.

One experiment was made with a paraffin cover at room temperature, the second one under the same conditions, but with a paraffin cover preliminarily cooled by liquid air. Six series of observations were made. Every time the silver activity was greater when using cooled paraffin. The mean increase of activity was equal to 23%.

The lead and the ampulla placed inside it were probably slightly cooled when covered with cold paraffin. It is well known that the condensation of radon on beryllium depends on its temperature. This brings about an increase of the effect at lower temperature because of the increase of the number of neutrons emitted by the ampulla. However, Dunning's tests with cooling the source to the temperature of liquid air show an increase of only 8%. In our experiments, the ampulla was known to have a temperature above that of the liquid air. Therefore, the condensation effect was less than 8% whereas the increase observed was 23%. One might suppose that the thin spherical paraffin layer slows down the neutrons in one test to the velocities of room temperature and in the other, to smaller velocities, corresponding to the temperature of liquid air.

However, this is not the case. The thin spherical paraffin layer does not produce any noticeable slowing down of fast neutrons emitted by the source (radon+beryllium), since only an insignificant part of fast neutrons collide with the protons within the paraffin. In order to explain the temperature-effect observed, it should be assumed that the neutrons inside the paraffin have acquired thermal velocities, i. e. have undergone dozens of collisions.

A comparison of the effect obtained (23%) with the maximum temperature effect (35%) for silver, obtained by a maximum preliminary slowing down of the neutrons within the paraffin, shows that inside our spherical layer there exist neutrons with small velocities. As such neutrons cannot be obtained through collisions in the paraffin, only the following two suppositions may be made: either the source itself (radon+beryllium) produces very many slow neutrons, or else the slow neutrons are formed while passing through the lead. The first possibility seems to be out of the question, which is confirmed by experiments in slowing down neutrons as well as those made for the study of the velocities of neutrons directly emitted by the source.

Notwithstanding the above-mentioned accessory phenomena resulting from the magnitude of the effect observed (23%), we come to the conclusion that while passing through the lead, slow neutrons are formed (possibly exceeding in velocity the thermal ones) which subsequently undergo a temperature effect in the paraffin.

As we have seen, such a considerable slowing down of the neutrons cannot be ascribed to elastic collisions of the neutrons with the nuclei of lead.

N. Bohr [7] regards the «scattering» of fast neutrons by heavy nuclei as the capture of the neutron by the nucleus with the distribution of the neutron energy to all the components of the nucleus, and the subsequent emission of one of the nucleus neutrons due to the fact that it had accidentally received a surplus energy sufficient for its exit out of the nucleus.

Such a redistribution of energy results in the heavy nucleus emitting very slow neutrons when capturing the fast neutrons. This brings about an increase of the reaction intensity, when surrounding the source with heavy elements, and the observed phenomenon of temperature effect.

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Received
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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

PHYSIK

DIE WIRKUNG EINES MAGNETFELDES AUF DAS DURCH GAMMA-STRAHLEN HERVORGERUFENE SICHTBARE LEUCHTEN DER FLÜSSIGKEITEN

Von P. A. ČERENKOV (TSCHERENKOW)

(Vorgelegt von S. I. Wawilow, Mitglied der Akademie, d. 7. VIII. 1936)

In einer früher veröffentlichten Mitteilung (1) wurde von uns eine universelle Eigenschaft aller reinen Flüssigkeiten beschrieben—ihre Fähigkeit, unter der Wirkung von γ-Strahlen mit sichtbarem Licht zu leuchten. Eine Reihe von Eigentümlichkeiten dieses Leuchtens: die Unempfindlichkeit gegen die Einwirkung von Auslöschungsfaktoren (Auflösung in den Flüssigkeiten aktiver Auslöschungsmittel der Fluoreszenz, Veränderung der Viskosität, Erwärmung), und die ungewöhnliche Richtung der hauptsächlichen Schwingungen des elektrischen Vektors u. a. unterschieden diese Art des Leuchtens in scharfer Weise von allen früher bekannten Arten der Lumineszenz. S. I. Wawilow hat die Vermutung (2) ausgesprochen, dass dieses von ihm als γ-Leuchten bezeichnete Leuchten eine Strahlung sei, die bei der Bremsung der durch Photonen primärer Radiation innerhalb der Flüssigkeit herausgeschlagenen Kompton-Elektronen entsteht. Vom Standpunkt dieser Hypothese aus ist zu erwarten, dass die Überlagerung des Magnetfeldes am Charakter des γ-Leuchtens zutage treten muss. Die Ergebnisse einiger in genannter Richtung vorgenommenen Versuche werden in vorliegender Arbeit mitgeteilt.

Das Magnetfeld wurde durch einen Elektromagnet erzeugt, der im Umfang von 31 cm³ ein Magnetfeld von ca 9500 Gauss gab. Der Abstand zwischen den Polen des Elektromagnets betrug gewöhnlich 22 mm. Die Polschuhenden hatten die Form eines Rechtecks von 20 × 70 mm² Flächeninhalt. Als Quelle der γ-Strahlen diente ein Radiumpräparat, zu welchem manchmal eine Ampulle mit Radiumemanation hinzugefügt wurde. Die Totalintensität der γ-Strahlung schwankte in einzelnen Fällen zwischen 0.5 und 1 Gramm-Äquivalent Radiums. Zur Absorption der β-Strahlen wurde die γ-Quelle von der Flüssigkeit durch ein Bleifilter von 1 mm Dicke getrennt. Die zur Aufnahme der Flüssigkeiten dienenden Gefässe waren aus Platina, Glas oder Messing. In sämtlichen Fällen (wenn kein besonderer Vorbehalt vorlag) hatte die Innenseite des Gefässes eine schwarze Deckung, um das Leuchten des Materials der Gefässwände (Glas) zu beseitigen und die Reflexion des Lichtes zu vermeiden. Auf Fig. 1 ist das Schema der Anordnung gegeben. Hier sind

R_1, R_2 und R_3 die angewandten Lagen der γ-Quelle, T—das Gefäss mit der Flüssigkeit. Die Ausmasse des Gefässes waren derart, dass es vollständig zwischen den Polschuhen lag, in einem ungefähr homogenen Magnetfelde. Das Magnetfeld lag senkrecht zu der Fläche der Zeichnung. Die Photometrierung wurde nach der bereits beschriebenen (1) Auslöschungsmethode ausgeführt. Die Beobachtungen erfolgten stets von oben.

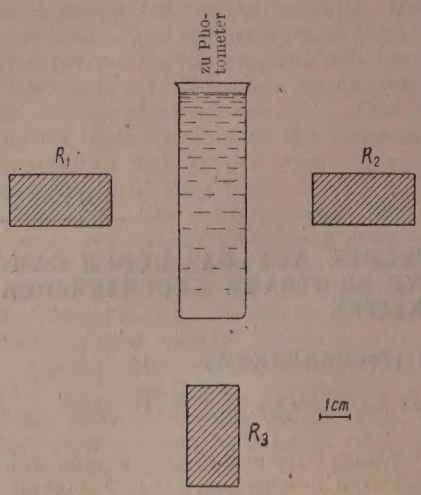

Fig. 1.

Die Messungen der Helligkeit des γ-Leuchtens zeigen, dass sich diese bei Vorhandensein eines Magnetfeldes von genügender Stärke scharf verändert. Bezeichnen wir mit H_+ ein Feld in einer vom Beschauer abgewandten Richtung (Fig. 1) und mit H_- ein Feld in entgegengesetzter Richtung, so:

a) verringert sich bei der Lage der γ-Quelle in R_1 die Helligkeit des γ-Leuchtens im Felde H_- im Vergleich zu der in Abwesenheit des Magnetfeldes gemessenen Helligkeit, während im Feld H_- die Helligkeit zunimmt;

b) findet bei der Lage der γ-Quelle in R_2 die entgegengesetzte Erscheinung statt: im Felde H_+ steigt die Helligkeit des γ-Leuchtens, im Felde H_- nimmt sie ab.

In der folgenden Tabelle sind die Ziffern angeführt, die die Grösse der Veränderung der Helligkeit des γ-Leuchtens im Magnetfelde kennzeichnen (bei der geometrischen Grundlage unseres Versuchs).

Tabelle 1

Magnetfeld von 9000 Gauss

Lage der Quelle	Gemessene Helligkeit des γ-Leuchtens			Bemerkungen
	im Felde H_+	ohne Magnetfeld	im Felde H_-	
In R_1	1.8	1	0.45	Wasser. Anz. d. Beob. 11
» R_2	0.5	1	1.9	» » » » 51
» R_3	0.96	1	0.95	Pentan. » » » 17

Wie aus der Tabelle zu ersehen ist (erste 2 Zeilen), verändert sich die zu messende Helligkeit des γ-Leuchtens bei Veränderung der Richtung des Magnetfeldes etwa um das Vierfache. Die dritte Zeile zeigt, dass keine Wirkung des Magnetfeldes auf die zu messende Helligkeit zu beobachten ist, wenn die γ-Quelle sich in R_3 befindet (unter dem Gefäss), was übrigens aus Gründen der Symmetrie auch zu erwarten war.

Der in Magnetfeldern entgegengesetzter Richtungen zu beobachtende bedeutende Unterschied in der Helligkeit des γ-Leuchtens lässt sich nicht durch irgendeinen Polarisationseffekt allein erklären (eine veränderte Verteil-

lung der Energie unter drei rechtwinklig zu einander liegende Komponenten der Schwingungen des elektrischen Vektors), denn die Messungen mit dem Polarisationsprisma zeigen, dass in bezug auf beide horizontalen Komponenten (der parallel und der senkrecht zur Achse des γ-Strahlenbündels liegenden) die Veränderung der Helligkeit in gleichem Sinne erfolgt. Andererseits wurde bei Beobachtungen längs der magnetischen Linien kein merklicher Unterschied in der Helligkeit des γ-Leuchtens im Magnetfelde und ohne dasselbe festgestellt. Der Unterschied in der Helligkeit lässt sich auch nicht durch die auslöschenden Faktoren oder entsprechend sensibilisierende Einwirkung des Magnetfe des auf das γ-Leuchten erklären. Dagegen sprechen Versuche, in denen die relne Flüssigkeit (z. B. Wasser) durch eine Wasserlösung von Äskulin ersetzt wurde ($c = 8.10^5 g/cm^3$). Es liegen Gründe vor für die Annahme, dass die unter der Wirkung der γ-Strahlen erfolgende Fluoreszenz dieser Lösung durch das γ-Leuchten des Lösungsmittels hervorgerufen wird.

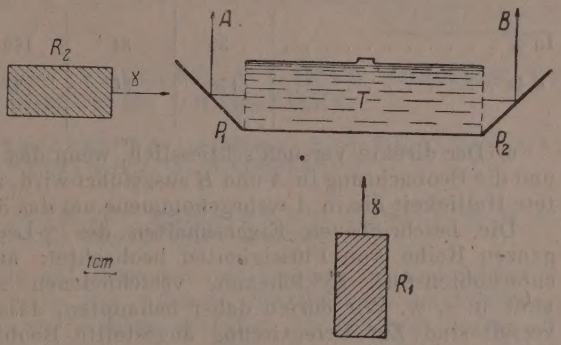

Fig. 2.

Fände unter der Wirkung des Magnetfeldes eine reale Veränderung der Totalintensität des γ-Leuchtens statt (im vollen Raumwinkel 4π), so würde sich dies unverzüglich an der zu beobachtenden Fluorszenzhelligkeit der Äskulinlösung äussern. Letzteres findet jedoch keine Bestätigung durch die Versuche, die unter analogen Bedingungen wie die mit reinen Flüssigkeiten vorgenommenen Versuche durchgeführt wurden: die Helligkeit der Fluoreszenz der Äskulinlösung bleibt konstant, sowohl im Magnetfelde als auch ohne dieses. Dasselbe Ergebnis wurde mit einer Lösung von Uranil-Sulfat in Schwefelsäure erzielt [wo die Anregung der Lumineszenz durch Elektronen hervorgerufen wird (3)].

Die Ergebnisse der oben dargelegten Versuche lassen darauf schliessen, dass die räumliche Verteilung der Intensität des γ-Leuchtens reiner Flüssigkeiten asymmetrisch ist und sich hauptsächlich nach vorwärts erstreckt, in der Richtung der Bewegung der Kompton-Elektronen. Durch die Wirkung des Magnetfeldes werden die Elektronen entweder dem Beschauer zu oder von ihm abgelenkt, und dem entsprechend ist in der betreffenden Richtung bald eine Zunahme, bald eine Abnahme der Helligkeit zu beobachten. Diese Annahme findet ihre volle Bestätigung durch folgende Versuchsergebnisse.

a) Macht man die Innenwände des Gefässes (Fig. 1) weis oder reflektierend, so verringert sich der Effekt des Helligkeitsunterschiedes in Magnetfeldern von entgegengesetzter Richtung, was durch die teilweise Reflexion des Lichtes in der Richtung des Beobachters bedingt ist.

b) Im Falle gleichzeitiger Beobachtung von zwei entgegengesetzten Seiten des Gefässes aus bewirkt die Einschaltung des Magnetfeldes auf der einen Seite eine Vergrösserung, auf der anderen dagegen eine Abnahme der Helligkeit des γ-Leuchtens. Das Schema eines derartigen Versuchs ist in Fig. 2 dargestellt. Hier ist T, wie auch früher, ein zylindrisches, an der Innenseite geschwärztes Gefäss mit durchsigtichen Grundflächen (feines Glas).

Das Radum befindet sich in R_1. Das Leuchten der in T befindlichen Flüssigkeit wird mittels der Spiegel P_1 und P_2 nach A und B gelenkt und von dort aus beobachtet. Das Magnetfeld (9400 Gauss) liegt, wie auch früher, senkrecht zur Ebene der Zeichnung. Die ziffernmässigen Ergebnisse dieses Versuchs sind in Tab. 2 angeführt.

Tabelle 2

Magnetfeld von 9400 Gauss

Beobachtungsstelle	Gemessene Helligkeit des γ-Leuchtens			Bemerkung
	im Feld H_+	ohne Magnetfeld	im Feld H_-	
In A	39	81	169	Wasser. Das Mittel aus 6 Ablesungen
» B	178	86	33	

c) Der direkte Versuch schliesslich, wenn das Radium sich in R_2 befindet und die Beobachtung in A und B ausgeführt wird, zeigt, dass die in B beobachtete Helligkeit die in A wahrgenommene um das 3—4 fache übertrifft.

Die beschriebenen Eigenschaften des γ-Leuchtens wurden an einer ganzen Reihe von Flüssigkeiten beobachtet: an Wasser, Pentan, Tetrachlorkohlenstoff, Zyklohexan, verschiedenen Alkoholen, Schwefelkohlenstoff u. s. w. Wir dürfen daher behaupten, dass diese Eigenshaften universell sind. Zur Orientierung angestellte Beobachtungen zeigen, dass der Effekt des durch das Magnetfeld ausgeübten Einflusses in Flüssigkeiten von geringerer Dichte schärfer zutage tritt. Bei einer Feldstärke von 5000 gauss ist der Effekt bei Wasser kaum bemerkbar, während er bei Pentan (d=0.63) schon deutlich wahrzunehmen ist. Das hängt wahrscheinlich damit zusammen, dass in einer weniger dichten Flüssigkeit das Elektron eine grössere Strecke zurücklegt und daher ein und dasselbe Magnetfeld eine grössere Ablenkung von dessen ursprünglicher Bahn hervorruft.

Alle oben dargelegten Tatsachen gestatten, mit Sicherheit zu schliessen, dass dem Mechanismus des γ-Leuchtens eine elektromagnetische Bremsung der sich in der Flüssigkeit bewegenden Elektronen zugrunde liegt. Der Umstand, dass das γ-Leuchten teilweise polarisiert ist und dessen Helligkeit das Merkmal einer scharf ausgesprochenen Assymetrie aufweist, erinnert stark an ein analoges Bild, das bei Bremsungen im Röntgengebiet bei schnellen Elektronen ([4]) zu beobachten ist. In bezug auf das γ-Leuchten stösst jedoch die vollständige theoretische Begründung der Erscheinung noch auf eine Reihe von Unklarheiten.

Die weitere Erforschung dieser Erscheinung wird von uns fortgesetzt.

Zum Schluss spreche ich dem Akademiker S. I. Wawilow und Dr. J. M. Frank meinen tiefgefühlten Dank aus für das meiner Arbeit entgegengebrachte Interesse und die Erteilung wertvoller Ratschläge bei deren Durchführung.

Lebedevsches physikalisches Institut.
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Eingegangen
d. 7.VIII.1936.

ZITIERTE LITERATUR

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

BIOPHYSIQUE

ÉTUDE DE L'ADAPTATION VISUELLE A L'ÉTAT NORMALE ET PATHOLOGIQUE DE L'ORGANISME.

Par P. P. LAZAREV (P. P. LASAREFF) de l'Académie, E. M. KLINKOVSTEIN, Z. V. BULANOVA et S. S. KATZNELSON

I. SUR L'INFLUENCE DE *DIABETES MELLITUS* SUR L'ADAPTATION AU COURS DE LA VISION PÉRIPHÉRIQUE

Les recherches d'Overton ont démontré que le sucre est une substance produisant la narcose des nerfs. En se basant sur quelques considérations théoriques Lasareff a admis que le même effet doit être observé dans les cellules des centres nerveux du cerveau.

Il était donc intéressant d'étudier le changement de la sensibilité des centres de la vision périphérique chez les personnes souffrant de diabète, vu que leur sang contient des quantités assez grandes de sucre.

Dans ce cas doit on attendre une diminution de la sensibilité de la vision périphérique?

Méthode

La méthode employée pour les mesures de l'adaptation visuelle (les mesures étaient éxécutées par Z. V. Bulanova), était la suivante. Après le séjour dans l'obscurité pendant 30 minutes on éclairait pendant 5 minutes les yeux de la personne étudiée. L'éclairage se produisait par la lumière diffuse d'une surface blanche, illuminée par une lampe électrique. Après l'éclairage la lumière fut éteinte et dans l'obscurité on mesura l'adaptation binoculaire avec l'appareil de Nagel.

D'après les valeurs observées de la sensibilité E, correspondant au temps t on calculait suivant la formule de Lasareff

$$E = E_0 - E_1 e^{-\alpha_3 t}$$

les valeurs E_0 et α_3.

E_0 représente le maximum de la sensibilité de l'œil proportionnelle à la sensibilité des centres de la vision périphérique, α_3 est un coefficient de la restitution du pourpre visuel dans l'obscurité; E_1 est une constante dépendant de l'intensité de la lumière qui agissait pendant 5 minutes sur les yeux, t est le temps de l'adaptation dans l'obscurité, e est la base des logarithmes de Neper. La détermination des valeurs de E_0 et α_3 était éxecutée avec l'appareil de Gamburceva.

Résultats

Dans la table 1—(*A*) et (*B*)—sont données les valeurs de E_0 [E_0 (obs.)] et α_3 déduites de l'observation. En même temps nous apportons les valeurs moyennes de E_0 correspondant à l'âge de la personne étudiée [E_0 (m.)].

Table 1

	(*A*) 49 ans						(*B*) 33 ans			
	26/I	27/I	28/I	29/I	30/I	31/I	24/I	25/I	26/I	27/I
% du sucre dans l'urine . . .	1.02	—	0.8	—	2.2	1.3	3.8	5.0	3	—
% du sucre dans le sang . . .	—	—	—	—	—	0.160	0.187	—	—	—
Acéton	—	—	—	—	—	Réact. posit.	—	—	—	—
E_0 (obs.) . . .	—	—	30	56	—	—	—	—	34	60
E_0 (m.)			68						86	
$\alpha.10^3$	—	—	38	38	—	—	—	—	38	38

De la table 1 nous voyons chez deux malades la diminution de E_0 en comparaison des valeurs moyennes normales de E_0. Cette loi s'observe chez toutes les personnes étudiées.

α_3 n'a pas sensiblement changé.

Le malade (*B*) a été traité avec insouline. L'influence de l'injection de l'insouline sur la sensibilité E_0 est représentée sur la table 2.

Table 2

	31/I	1/II	4/II
E_0	180	150	118
Dose de l'insouline en unités	20	20	40

La sensibilité avant les injections variait entre 34 et 60.

Comme on voit, les injections de l'insouline produisent un accroissement de la sensibilité E_0.

Il est intéressant de remarquer que la première injection de l'insouline produit un très grand accroissement, de E_0—depuis 34 et 60 (avant l'injection) jusqu'à 180 (après l'injection).

Les injections suivantes donnent le même effet mais l'accroissement est moindre (la seconde injection donne E_0=150, la troisième, avec une dose double, donne E_0=118).

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Manuscrit reçu
le 8. VII. 1936.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

HYDRODYNAMICS

ON THE PROBLEM OF MOTION OF A GAS IN TWO DIMENSIONS

By N. A. SLIOSKIN

(Communicated by S. A. Chapligin, Member of the Academy, 21. VII. 1936)

In our note (1) we extended the approximate method of S. Chapligin to the case of a steady motion with a free surface past a curved arc. In Demtchenko's notes (2) this approximate method of S. Chapligin is extended also to case of continuous motion in two dimensions.

In the present note we want to indicate the possibility of solving the problem of the continuous motion of a gas in two dimensions without circulation by the same method of the jet theory that was applied in our previous note.

Let us suppose that a plane stream of gas having at infinity a velocity equal to q_0 flows past a fixed cylinder whose section is a closed curve without any angular points. For this stream, according to S. Chapligin's approximate method, $\omega = \vartheta + i\sigma$ is a function of a complex variable $w = \varphi + i\psi$.

Let $\psi = 0$ be the stream-line including a given contour, φ_1 and φ_2, the values of a velocity potential φ at the points of divergence and convergence of the line $\psi = 0$ respectively. Then the region occupied by the moving fluid corresponds to the whole plane w slit from φ_1 to φ_2 along the real axis. Let this region in the plane w be represented outside a circle of a unit radius of a plane of a variable u:

$$w = \frac{\varphi_2 - \varphi_1}{4}\left(u + \frac{1}{u}\right) + \frac{\varphi_1 + \varphi_2}{2}. \tag{1}$$

The function $\omega(w)$ vanishes at infinity and is regular throughout with the exception of the points $w = \varphi_1$ and $w = \varphi_2$, where its real portion suffers a break equal to π. This function may be written in the region of the variable u thus:

$$\omega(u) = i \ln\left(1 + \frac{1}{u^2}\right) + \Omega(u), \tag{2}$$

where $\Omega(u)$ is regular both outside and on the circle. Let $z = x + iy$ be the plane of the stream. Then we have:

$$dz = \frac{\varphi_2 - \varphi_1}{4}\left[ae^{i\Omega(u)}\, du + b\left(\frac{\overline{u^2} - 1}{u^2}\right)^2 e^{i\Omega(u)}\right], \tag{3}$$

and the total pressure on the contour is

$$Y + iX = \frac{\rho_0(\varphi_2 - \varphi_1)}{8a} \int e^{-i\Omega(u)} \left(1 - \frac{1}{u^2}\right)^2 du. \tag{4}$$

Let $u = e^{i\alpha}$, $\Omega(e^{i\alpha}) = T + i\Theta$ be on the circle. Then we have the following formulae for the velocity, the curvature and the equations of the contour:

$$q = \frac{2\sin\alpha}{ae^{-T} + 4b\sin^2\alpha e^{T}}; \tag{5}$$

$$\frac{1}{\rho} = \frac{4}{\varphi_2 - \varphi_1} \frac{1}{ae^{-T} + 4b\sin^2\alpha e^{T}} \left(1 + \frac{d\Theta}{d\alpha}\right); \tag{6}$$

$$dz = i\frac{\varphi_2 - \varphi_1}{4} e^{i(\Theta+\alpha)} [ae^{-T} + 4b\sin^2\alpha e^{T}]\, d\alpha. \tag{7}$$

It is possible to study the individual cases of motion by two methods: either to establish the function $\Omega(u)$ and to find an appropriate contour from formula (7) or to find $\Omega(u)$ from the established closed curve. In the first case, it is necessary that the expansion of $e^{i\Omega(u)}$ in the vicinity of an infinitely distant point should contain no variable u in the first negative exponent, or else z, determined from (3), will not be a single-valued function of u and $\bar{u}$. Under such condition it is easy to prove from (4) D'Alamber's paradox: if a cylinder moves with a constant velocity in a gas, the resultant force acting on it is equal to zero.

Let us consider the following example according to this method: $\Omega(u) = 0$, $\varphi_2 = -\varphi_1 = \varphi_0$.

From (7) the closed curve is given in parameter equations:

$$\begin{aligned} x &= \frac{\varphi_0}{2}\left[(a + 4b)\cos\alpha - \frac{4b}{3}\cos^3\alpha\right] + x_0, \\ y &= \frac{\varphi_0}{2}\left[a\sin\alpha + \frac{4b}{3}\sin^3\alpha\right] + y_0. \end{aligned} \tag{8}$$

The radius of curvature of this curve equals

$$\rho = \frac{\varphi_0}{2}[a + 4b\sin^2\alpha],$$

and its whole arc equals

$$L = \varphi_0\pi(a + 2b).$$

To solve the problem by the second method, we establish the integro-differential equation of the problem. Let us assume that the contour is given in the form of the intrinsic equation $\rho(\theta)$. Since on the contour $\theta = \alpha - \frac{\pi}{2} + \Theta$, the function $\rho(\Theta, \alpha)$ will be known. Using the equation of Dini:

$$T(\alpha) = -\frac{1}{2\pi} \int_0^{2\pi} \Theta(\varepsilon) \log\left(4\sin^2\frac{\varepsilon - \alpha}{2}\right) d\varepsilon,$$

from (6) we obtain:

$$T(\alpha) = -\frac{\varphi_2 - \varphi_1}{8\pi} \int_0^{2\pi} \frac{1}{\rho(\varepsilon, \Theta)} [ae^{-T(\varepsilon)} + 4b\sin^2\varepsilon e^{T(\varepsilon)}] \log\left(4\sin^2\frac{\varepsilon - \alpha}{2}\right) d\varepsilon. \tag{9}$$

If we eliminate Θ from (9) by the second formula of Dini, Equation (9) will be the integro-differential equation of the problem.

For the circle $\rho = R$, $\varphi_2 = -\varphi_1 = \varphi_0$, $\lambda = \frac{\varphi_0}{16\pi R q_0}$ we have from (9) the following integral equation:

$$T(\alpha) = -\frac{\lambda q_0}{4} \int_0^{2\pi} [ae^{-T(\varepsilon)} + 4b \sin^2 \varepsilon e^{T(\varepsilon)}] \log\left(4 \sin^2 \frac{\varepsilon - \alpha}{2}\right) d\varepsilon. \qquad (10)$$

This integral equation is readily solved by the method of successive approximations. The first two approximations are as follows:

$$T_1 = -\frac{\lambda b q_0 \pi}{2} \cos 2\varepsilon,$$

$$T_2 = -\frac{\lambda b q_0 \pi}{2} \cos 2\varepsilon + \frac{\lambda^2 b \pi^2 q_0^2}{16} [(2a - 4b) \cos 2\varepsilon + b \cos 4\varepsilon]. \qquad (11)$$

The convergence of the process of successive approximations may be easily proved: the radius of convergence satisfies the inequality

$$\lambda \leqslant \frac{0.37}{1 - (1 - \tau_0)^{-\beta}}. \qquad (12)$$

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Received
21. VII. 1936.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

CHEMISTRY

THERMAL DECOMPOSITION OF OLEFINIC HYDROCARBONS

By M. MICHAILOV and J. A. ARBUZOV

(Communicated by N. D. Zelinskij, Member of the Academy, 2. IV. 1936)

The pyrolisis of olefinic hydrocarbons has been far less studied than that of saturated hydrocarbons. The study of the thermal decomposition of ethylenic hydrocarbons is complicated by the processes of condensation and polymerization, which proceed simultaneously with the splitting-up of the olefine molecule. The formation of condensation products is observed in all cases of pyrolisis of olefines and sometimes on a large scale. Thus, the pyrolisis of butene-1 and butene-2 at 650° yields as much as 30% liquid products, while the pyrolisis of isobutene yielded, according to Hurd and Spence (2), as much as 63% condensation products. Butadiene enters most readily into the reaction of condensation. Wheeler and Wood (1) have shown that, if a mixture of 12.8% butadiene and 87.2% ethylene is passed through a tube heated to 600°, 22.4 l of mixture yields 3.8 g liquid products, not more than 1.9% of butadiene remaining in the gas.

The picture of the thermal decomposition of olefinic hydrocarbons is obscured to a very great extent by the processes of condensation, it thus being impossible to form a correct idea of the quantitative ratio of the primary decomposition products. With a view to avoiding the formation of large amounts of condensation products, we studied the decomposition of olefinic hydrocarbons at low partial pressures and a brief time of contact (0.4—1.0 sec.). To lower the partial pressure of the vapours of the hydrocarbons to be decomposed, they were diluted with steam. Under these conditions, the main decomposition products were gaseous hydrocarbons; as to products having their boiling points above those of the initial hydrocarbons, their percentage did not exceed 2—6%.

We subjected to thermal decomposition pentene-1, pentene-2, hexene-1 and 4-methyl-pentene-1.

P e n t e n e -1. The pyrolisis of pentene-1 was recently studied by Hurd, Goodyear and Goldsby (3) at 550—600°, the gaseous products amounting to somewhat more than a half of the total reaction products. The molar quantities of methane, butene-1, propylene, ethane and ethylene were in the ratio of 6:2:2:1. We carried out the decomposition of pentene-1 at 600 and 650°. The gaseous products obtained in these experiments were very similar in

composition, but differed very considerably as to composition from the gas obtained in the work cited above. Rather remarkable is the high percentage of butadiene (12—13%) in the gas.

Pentene-2. The pyrolisis of pentene-2 has been studied by Norris and Reuter ([4]) and also by Hurd ([3, 5]). In decomposing pentene-2 at 600°, Norris and Reuter found that 2/3 of the reaction products were gaseous hydrocarbons while 1/3 were hydrocarbons having a higher boiling point than the initial substance. The molar rations of the gaseous hydrocarbons obtained were as follows: methane 100, butadiene 30*, butene 27, propylene 21, and ethylene 15. Hurd, Goodyear and Goldsby ([3]) obtained from pentene-2 at 600° about 45% condensation products. The gaseous reaction products were of practically the same composition as in the experiments of Norris and Reuter, but the yield of butadiene was very low. We decomposed pentene-2 at 600 and 650°. Among the reaction products, 2.5—6% were hydrocarbons having higher boiling points than the initial pentene. The gaseous products contained a high percentage of methane (40—47.9%) and of butadiene (15.1—15.6%).

Hexene-1. The thermal decomposition of hexene-1 was carried out by the writers at 650 and 700°. The gaseuos reaction products were mainly ethylene (40%) and propylene (30%). Only 4.3—5.8% butadiene was contained in the gas.

4-methyl-pentene-1. The pyrolisis of this hydrocarbon has been studied by Hurd and Bollman ([6]). These authors observed the formation of fairly large amounts of condensation products. The gaseous reaction products varied considerably in composition from one experiment to another and contained a high percentage of saturated hydrocarbons (29—52%) and of propylene (27—42%). In our experiments on the decomposition of 4-methyl-pentene-1 at 550, 600 and 650°, propylene (58—60%) was the principal decomposition product. Very little butadiene was obtained.

EXPERIMENTAL

The Obtention of the Initial Substances. The pentene-1, obtained by a Grignard reaction from ethyl bromide, magnesium and allyl chloride ([7]), had the following constants: b. p. 29—29°5 (751 mm); $d_4^{20}=0.6483$; $n_D^{19.6}=1.3734$.

The pentene-2 was obtained by the dehydration of pentanol-3 ([8]) and had the following constants: b. p. 35.9—36° 5 (760 mm); $d_4^{20}=0.6509$; $n_D^{14.2}=1.3827$.

The hexene-1 was obtained from propyl bromide, magnesium and allyl chloride after Grignard. The reaction was carried out as described by Waterman ([9]) in his work on the preparation of heptene-1. The preparation had the following constants: b. p. 63—64° (745 mm); $d_4^{20}=0.6726$; $n_D^{21}=1.3870$.

The 4-methyl-pentene-1 was synthesized after the method of Schmidt and Boord ([10]) and had the following constants: b. p. 52.5—54° (760 mm); $d_4^{20}=0.6638$; $n_D^{19.5}=1.3839$.

Apparatus and Method of Analysis. Both the hydrocarbon and the water were conveyed from burettes into a receiver heated to 120—140°. The mixture of hydrocarbon vapours and steam was admitted into a quartz tube, inside diameter 18 mm, wound round with a nichrome wire over a distance of 40 cm and covered with a layer of asbestos. The tem-

[1] The butadiene was determined as a tetrabromide.

Results of Experiments on the Decomposition of Pentene-1, Pentene-2, Hexene-1 and 4-Methyl-Pentene-1

Nos of experiments	Substance	Temperature, °C	Duration of experiment (in minutes)	Substance taken (grams)	Rate of delivery of substance (cm³/min)	Rate of delivery of water (cm³/min)	Liquid condensate, grams	Decomposition, %	Vol. (S. T. P.) of exit gas, litres	Analysis of exit gas, % by volume								
										Hydrogen	Methane	Ethylene	Ethane	Propylene	Propane	Butadiene	Butenes-1 and-2	Isobutene
1	Pentene-1 . . .	600	78	25.2	0.5	1.4	16.4	34.0	2.79	2.6	18.2	30.9	7.0	20.1	0.5	13.0	7.7	—
2	» . . .	650	60	20.0	0.5	1.4	6.5	70.0	6.10	3.1	17.8	32.9	6.9	21.2	0.6	11.9	5.6	—
3	Pentene-2 . . .	600	146	36.0	0.38	1.0	29.1	21.0	2.28	6.6	47.9	14.5	5.0	5.4	—	15.5	5.1	—
4	» . . .	650	46	13.0	0.4	1.5	6.8	61.0	3.19	6.7	40.4	17.2	4.1	10.0	—	15.6	6.0	—
5	Hexene-1 . . .	650	75	24.4	0.5	1.7	14.0	64.0	4.81	1.8	11.2	40.3	2.3	30.2	—	4.3	9.9	—
6	» . . .	700	43	14.5	0.5	1.8	2.6	90.0	6.29	2.4	11.9	40.0	1.4	28.0	—	5.8	10.5	—
7	4-methylpentene-1	550	115	36.7	0.5	0.7	28.5	26.0	2.84	6.2	10.2	14.7	3.2	60.6	—	0.6	3.5	1.0
8	»	600	87	30.0	0.5	1.4	18.9	50.0	5.69	6.9	9.3	17.0	1.2	59.3	0.3	0.9	4.1	1.0
9	»	650	49	16.9	0.5	1.8	5.3	75.7	6.16	7.9	8.0	16.3	0.9	58.4	0.2	1.9	5.3	1.1

perature was measured in the centre of the heated area by a platinum and platinum-rhodium thermocouple placed inside a quartz well. The variations of temperature were well within ±5°. One end of the quartz tube to the extent of 12 cm, was refrigerated with a freezing mixture. The products issuing from the furnace were first admitted into an ice-cooled receiver, where the water and, practically, all the liquid products were collected; they were subsequently passed through another receiver placed in a Dewar vessel containing a mixture of solid carbon dioxide and ether and connected to a gas-holder. After the experiment the second receiver was connected to a Vigreux fractionating column cooled externally to 0—5°, and heated. The gaseous products were collected in the gas-holder, the remainder being joined to the condensate collected in the first receiver.

The gaseous decomposition products were fractionated with a Podbilnyak apparatus, the individual fractions being then analysed by the absorption method in Orsat apparatus. The saturated hydrocarbons and the hydrogen were determined by burning over copper oxide; the butadiene was determined in a Korotkov apparatus.

Vigreux fractionating column was used to separate from the liquid reaction products those fractions which correspond to the unchanged initial hydrocarbon.

The results of the experiments are represented in the table.

Conclusions

1. The thermal decomposition of pentene-1, pentene-2, hexene-1 and 4-methyl-pentene-1 in an excess of water vapour has been studied.

2. It has been shown that under these conditions, gaseous hydrocarbons are the main products of decomposition of olefinic hydrocarbons, the amount of condensation products being negligible.

3. It was been found that the thermal decomposition of pentene-1 and pentene-2 yields a considerable amount of butadiene. At 600°, pentene-1 yields 13 mol.% of butadiene while pentene-2 yields 15.6 mol.% of butadiene at 650°.

4. Propylene (about 60 mol.%) is the main product of decomposition of 4-methyl-pentene-1.

The writers express their gratitude to N. D. Zelinskij, member of the Academy, for his kind advice and the interest he has constantly taken in the present work.

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Received
2. IV. 1936.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

BIOCHEMISTRY

ON THE FORMATION OF OXALIC AND CITRIC ACIDS BY FUNGI

By V. S. BUTKEVIC (BUTKEVITCH), Corresponding Member of the Academy

In their recently published papers, Chrzaszcz and Zakomorny ([1], [2], [3]) endeavour to confirm by fresh experiments their former conclusions as to the formation of oxalic through formic acid ([4]) and of citric through acetic acid ([5]), having apparently accepted our opinion that their former experiments in this field were not conclusive enough ([6],[7]). Their new experiments, however, must be pronounced, in spite of their greater complexity, as inconclusive as the former ones.

A seven to ten day mycelium grown on malt wort and abounding in spores was used in the experiments. The mycelium was washed in water to remove the substances capable of reducing Fehling's solution, dried at 35°, crushed to powder in a mortar, definite amounts of the powder so obtained being introduced into solutions of calcium formate or calcium acetate, with an addition of KH_2PO_4, NH_4NO_3 and $MgSO_4$. These cultures, if allowed to stand at 29—30° for a few days, produced mycelium, the amount of both mycelium and spores being greater than that originally introduced.

The description of the experiments does not specify either the method of washing the mycelium before it was introduced, or that of determining the accretion of mycelium that took place in the course of the experiment. The rinsing of a live mycelium in water could not, of course, remove the substances contained in its cells. The mycelium obtained in the experiments with calcium formate or calcium acetate was bound to contain calcium oxalate and calcium citrate. The question is whether these were removed at the time of the determination of the weight of the mycelium and what procedure was used in their removal. These very essential gaps in the description of the experimental procedure render the results set forth in the paper somewhat difficult of interpretation.

According to the authors a fresh growth of mycelium took place in the above cultures containing salts of formic and acetic acids, these acids being used as a sourse of carbon.

The cultures containing calcium formate ([1]) accumulated mainly $CaCO_3$ and to a certain extent calcium oxalate. The procedure used in these experiments, however, does not warrant the conclusion that the formic acid was directly responsible for the formation of oxalic acid, which was found to have accumulated in certain cases. It is abundantly clear that the oxalic

acid could have been produced by the newly-formed mycelium, or by the substances contained in the mycelium that had been originally introduced.

Starting from the accretion of mycelium observed in their cultures, the above writers conclude that «the formation of oxalic acid is not in this case due to any loss of the substances contained in the mycelium, as suggested by Butkevitch and his collaborators». But Butkevitch and his collaborators have never asserted that the formation of oxalic acid in fungous cultures must always have for its concomitant a loss in the weight of the mycelium. There are some well known cases of the accumulation of oxalic acid in cultures even in the presence of an increase of mycelium (e. g. when the growth of a fungus likely to form oxalic acid is accompanied by the liberation of a base capable of fixing it). The accumulation of oxalic acid in a culture may be accompanied by an increase in the weight of the mycelium if the loss of substances by the latter is made up by its increasing growth.

Without examining the secondary arguments urged by the above authors in favour of a direct participation of formic acid in the formation of oxalic acid, we shall but state that not one of them is such as to make it imperative for us to accept this conversion scheme.

Among the statements made by the above authors there is only one that compels acceptance, namely that the ability of some fungi, in the presence of a free base in the solution, to accumulate oxalic or carbonic acid depends on the individual peculiarities of the fungus. At the same time it is but fair to state that this had been definitely proved by us as early as 1902, in our first paper on the conversion of peptone by fungi (9), so that the claim of the above authors to have discovered in different fungi a different ability to store up oxalic acid can only be accounted for by the fact that they have no knowledge of that work. As to the connection between the formation of oxalic acid and ammonia on peptone cultures, a question thouched upon by the above authors, we are of the opinion that in the case of some fungi likely to store up oxalic acid, such as *Asperg. niger* (10) and some varieties of *Citromyces* (11), this connection is fairly obvious and its existence has been adequately proved by our experiments. Another fact shown by our experiments is that these relations are not apparent in all varieties of fungi (some species of *Penicilium*, *Mucor* and others (6).

As may be seen from the above, the new work of Chrzaszcz and Zakomorny does not in any way alter the position as regards the problem of the formation of oxalic out of formic acid. On the other hand, the experiments recently made in this country by Osnitskaya and described in another communication (8) show conclusively that formic acid has no part whatever in the formation of oxalic acid.

As to the experiments with calcium acetate (2), where some quantities of citric acid had accumulated along with oxalic acid it should be noted that the amounts of the former were in all cases smaller than those of the mycelium introduced into the experiment, so that it may possibly have been formed out of the substances contained in the mycelium (the acetate exercising the protective action shown by us) (6).

As to our remark with regard to former experiments to the effect that the formation of citric acid from mycelium ought to be regarded as impossible only if the amount of acid formed is greater than the loss in weight of the fungous film, such a remark could obviously refer to such conditions only where no accretion takes place during the experiment. Such conditions were observed to exist in former experiments with the acetate and with no addition of nutritive salts.

In the second set of experiments ([2]), where some sugar had been added to the acetate, a large amount of citric acid was accumulated, and the accumulation increased with an increased percentage of sugar. There is no doubt that in these experiments the citric acid had been formed mainly from sugar. The above-mentioned writers, however, upon comparing the amount of sugar introduced into the experiment with that of citric acid obtained arrive at a different conclusion, viz., that the citric acid had been formed from the acetic acid. The comparison whereupon this conclusion is based, is, however, vitiated by a very essential error in the amount of sugar used in the experiment. «An addition of 0.5 g of sugar,—the authors write,—might have at best increased the amount of citric acid by 0.4 g. As a matter of fact, the increase amounts to about 1.8 g.» The amount of sugar that had been added was not 0.5 g, but 5%; this, considering that the experimental solution to which the citric acid in question is referred amounted to 500 cm³, would give as much as 2.5 g, a quantity fully sufficient to account for the amount of citric acid in question.

It may in general be stated that, in spite of the new experiments made by Chrzaszcz and Zakomorny, the views previously formulated by us remain in force. If, in order to obtain a positive result with regard to the accumulation of oxalic and citric acid, mycelium had to be introduced along with the spores, this is merely due to the fact that the latter was responsible for the formation of those acids. Should we accept the interpretation suggested by the above-mentioned authors the introduction of mycelium seems to have no purpose, and it is exactly this experimental procedure that is the least likely to warrant their point of view.

Nor is the scheme outlined by the authors in question in any way confirmed by the fact that, as observed by them, the accumulation of citric acid with acetate and sugar ([3]) is favourably affected by sodium malate. Without going into the particulars of all the interpretations of this influence that might possibly be suggested, we shall merely state that it can be quite naturally accounted for by the scheme of Raistrick and Virtanen ([12]), according to which the oxalo-acetic acid takes part in the formation of citric acid, but no splitting up of sugar as observed in alcoholic fermentation, takes place in this case. As to that splitting up, which, according to the scheme of Chrzaszcz, is a stage preceding the formation of citric and oxalic acids from sugar, we have now obtained some data which absolutely disprove any such splitting up. These data are: 1) yields of citric acid amounting to nearly 100% of the sugar taken ([12]) (according to the scheme with the splitting-up of sugar as observed in alcoholic fermentation, these yields cannot exceed 71%), and 2) the formation of both citric and oxalic acid in media with such a content of monoiodine-acetic acid that practically paralyses the aptitude of the fungous film to undergo alcoholic fermentation. The evidence, so far unpublished, relating to point 2) was obtained in our laboratory by Barinova, and similar data have been published by Walker [13]) with regard to citric acid.

Consequently, the schemes according to which citric and oxalic acids are derived from sugar owing to its splitting up as in alcoholic fermentation ought to be given ip, and new methods sought to account for the processes underlying these transformations.

As working hypotheses in this field we may provisionally adopt the schemes suggested by Raistrick and Clark ([14]), Virtanen and Pulkki ([15]), and Butkevitch ([16]), which are on the whole related to each other ([12]).

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Received
2. VIII. 1936.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

BIOCHEMISTRY

ON THE BIOSE/MONOSE RATIO AS A BIOCHEMICAL VARIETAL CHARACTER IN THE ONION

By B. A. RUBIN

(Communicated by A. N. Bach, Member of the Academy, 2. VII. 1936)

In the course of investigating, during a number of years the varietal differences in the stability of vegetables when being kept, our attention was drawn to a markedly manifested difference in the composition of soluble carbohydrates in varieties of onions of poor and of good keeping qualities. In a variety of onions of good keeping qualities, the predominating sugar in the soluble carbohydrate group proved to be saccharose, while in an unstable variety, it was monose. These differences in composition of sugars between varieties held with remarkable regularity during a long course of observation, despite the fact that within the bounds of one and the same variety the $\frac{\text{biose}}{\text{monose}}$ ratio changed greatly in dependence on the length of time during which the vegetables were kept (1).

Thus, for example, in the case of the Spanish onion, of poor keeping qualities, the $\frac{\text{biose}}{\text{monose}}$ ratio changed from 1.38 (November) to 0.32 (April). In the Rostov variety, which keeps well, it changed from 4.90 to 1.06 respectively.

An analogous relation between keeping qualities and the value of the $\frac{\text{biose}}{\text{monose}}$ ratio was observed in white-headed cabbage, as well.

An investigation carried on together with L. I. Naumova in the Institute of Vegetable Economy (2) into the composition of sugars in onions during the vegetation period showed that the rule ascertained for varieties during the period of keeping holds here also, as may be seen from the following table.

On the basis of conceptions developed of recent years by A. I. Oparin (3) on the nature of the action of ferments in the living cell and on the two different states of ferments (micro- and macro-heterogeneity), with which the direction of its action is conneted, we have advanced the hypothesis that the differences observed by us between varieties of onions in the composition of carbohydrates are due to qualitative differences in the fermentative apparatus (4).

Table 1

The $\frac{\text{biose}}{\text{monose}}$ Ratio in Onions during the Vegetation Period

Phase of development	The Rostov onion biennial of excellent keeping qualities		The Kaba onion annual of poor keeping qualities	
	Leaves	Bulb	Leaves	Bulb
4 to 5 leaves	0.4	2.08	0.18	0.65
Branching	0.08	2.52	0.01	0.32
Maturity	—	12.8	—	1.08

In the case of annuals, onions of poor keeping qualities, we deal with a biological system in which of the two properties of saccharase (hydrolysis and synthesis), the first predominates. In biennials, onions of excellent keeping qualities, on the contrary, synthesis predominates.

This article deals with a test of the latter hypothesis.

1. In January of 1936, together with O. T. Lutikova, we conducted an investigation of the composition of sugars in bulbs on a number of varieties of onions includig both annual and biennial forms *.

Besides this, a part of the bulbs were planted, and in the seedlings grown the hydrolytic and synthetic activity of saccharase was determined by the method of vaccuum infiltration ([5], [6], [7], and [8]).

The data obtained are presented in Table 2.

Table 2

№	Name of Variety	Bulbs		Seedlings		
		Soluble carbohydrates	Saccharose / Monoses	Saccharase in mg of sugar per 10 g of live leaves in 1 hour		
				Hydrolysis	Synthesis	Synthesis / Hydrolysis
1	Kaba	2.72	0.11	15.0	8.5	0.57
2	Maderski	4.48	0.81	15.0	6.7	0.52
3	Tsitausski	5.00	0.91	14.4	6.2	0.43
4	Miachkovski	7.02	1.71	5.1	15.0	2.94
5	Bessonovski	6.29	18.7	9.1	19.4	2.13
6	Elabuzhski	6.96	7.79	6.0	26.1	4.35
7	Msterski	7.44	6.83	7.3	14.6	2.00
8	Arzamasski	7.91	2.77	10.6	20.0	1.89
9	Alatyrski	8.01	21.3	21.2	30.6	1.39
10	Danilovski	8.41	3.98	14.6	21.8	1.49

Analysis of the bulbs showed that both in the gross sugar content and in the magnitude of the $\frac{\text{saccharose}}{\text{monoses}}$ ratio, the difference between varieties is remarkably great.

* Pure-strain material of the best quality was received for this work from the All-Union Institute of Vegetable Economy, for which we acknowledge our indebtedness.

The following law is very plainly expressed in the table: a rise in the general sugar content in the bulb is connected with an increase, both absolute and relative, in the amount of saccharose.

In conformity with facts hitherto established, it is to be noted that in annual onions (Kaba, Maderski, Tsitausski) the predominating sugars are the monoses, while in the biennial varieties this form of sugar is inconsiderable, and in any case, many times less than the saccharose.

Determinations of the activity of saccharase in the seedlings showed that the relations between monoses and bioses in the bulb reflect the characteristics of the fermentative system of the plants, i. e. the relations between the hydrolysing and sythesizing capacity of the saccharase. In the varieties of onions in the composition of whose carbohydrates saccharose predominates, the synthetic action of saccharase prevails over the hydrolytic. Owing to this, the ratio of the quantity of saccharose synthesized from monose to saccharose hydrolised is in the biennial onions always greater than unity and amounts in some cases to 3 or even 4 (Elabuzhski variety). In contradistinction to these forms, in the annual onions, the synthetic action of saccharase is only about half of the hydrolytic one.

In the majority of varieties of onions investigated, analyses were carried out on bulbs obtained both from seed and from sets.

The investigation showed that the value of the $\frac{\text{bioses}}{\text{monoses}}$ ratio is exceptionally constant as a varietal character.

Table 3

Variety	Bulbs obtained from seed		Bulbs obtained from sets	
	Total sugar in percentages	Monoses in percentages of the total	Total sugar in percentages	Monoses in percentages of the total
Danilovski 301	8.13	26.4	8.69	14.3
Miachkovski 561	7.14	33.6	6.89	31.6
Tsitausski 581	5.25	48.2	4.76	52.5
Msterski 335	7.15	14.3	7.73	11.4
Arzamasski 358	8.93	10.4	6.88	19.1

Besides this, in three of varieties investigated, there were at our disposal bulbs grown at different geographical points (Table 4).

Table 4

Variety	Source of material			
	Gribovskaya station		MSPO Base	
	Total sugar	Monoses in percentages of the total	Total sugar	Monoses in percentages of the total
Kaba	2.54	91.8	2.90	88.3
Tsitausski	5.00	50.3	6.56	48.0
Maderski	4.48	55.1	3.88	52.3

The figures (just shown) resulting from analyses of these onions show how constant a character of variety is the composition of its sugars.

The data here cited are in our opinion of exceptional interest. It must be pointed out, first of all, that the close relation between the general content in the storage organs of plants and the qualitative composition of the sugars and the increase of the general sugar content with the absolute and relative increase of the amount of bioses—can be established not only for the onion but for a number of other crops. Such are, for example, beets, in which the differences in the general sugar content in various strains, which attain very great magnitudes, prove to be closely connected with differences in the qualitative composition of the sugars. (The stock beet, with 4 to 5 per cent of sugar, has half this quantity in the form of monoses. The sugar beet, with a sugar content 3 to 4 times higher, contains 5 to 6 times less monoses than the stock beet).

Analogous conclusions may be based on data from the literature ([9], [10], [11]) on watermelons, some average from which are shown in Table 5.

Table 5

	Monose	Saccharose	Total	Saccharose / Monose
Citr. aedilus	4.36	3.68	8.04	0.84
Citr. colocynthoides	4.27	0.94	5.21	0.22
Citr. fistulosis	2.15	0.19(00)	2.34	0.09
Citr. colocynthis	0.70	0.0	0.70	0.0

Along with the relation noted above between composition of sugars and their quantity, it is apparent from the figures that within the limits of one and the same genus, there are species that do not form saccharose at all, as likewise those whose capacity to form sugar is well-marked.

There is every ground to suppose that the evolution of the chemical composition of the plants discussed here (onion, beet, watermelon) has been intimately related to the evolution of saccharase and, more exactly, with the increase of the synthesizing capacity of this ferment.

Confirmation of the principles we have developed in further investigations would open an important perspective in the matter of practical plant breeding.

In concluding, I consider it an agreable duty to thank O. T. Lutikova for the great aid she rendered in carrying out this investigation.

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Received
2. VII. 1936.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

GEOLOGY

BOUNDARY BETWEEN THE PERMIAN AND THE CARBONIFEROUS IN THE REEF LIMESTONES OF THE URALS ESTABLISHED ON THE BASIS OF THE *BRYOZOA* ENCLOSED THEREIN

By A. NIKIFOROVA

(Communicated by A. A. Borissiak, Member of the Academy, 18. VI. 1936)

The problem of the boundary between the Permian and the Carboniferous is one of the most burning questions of modern stratigraphy; an evidence of this is its inclusion in the program of the 17th Session of the International Geological Congress. Opinions concerning this question are extremely different: on the one hand, some British geologists (Dr. Sherlock, for instance) (1) have been inclined to deny the significance of the Permian as an independent system and, accordingly, proposed to abolish it. On the other, Grabau (2) and Schuchert (3) run to the opposite extreme in referring all the deposits of the «Upper Carboniferous» of the Urals and Moscow Basin to the Lower Permian.

The problem of the boundary between the Permian and Carboniferous of the Urals still can not be considered to be satisfactorily solved; although there are no such extreme opinions among Russian geologists as those stated above, yet divergencies are still rather considerable.

The Upper Paleozoic *Bryozoa*, to which this paper is devoted, have not thus far been taken into consideration in discussing this problem, despite their being very abundantly represented in the Urals, an evidence of which is found in the names given to the limestones occurring there, viz., the *Bryozoa* limestone, *Bryozoa* reef, etc.

This fact finds its explanation chiefly in our poor knowledge of the Upper Paleozoic *Bryozoa* in general. Thus, outside the territory of the USSR, the Lower Permian *Bryozoa*, at present, have been satisfactorily studied but from two points of the globe, tha Salt Range (India) (6) and the Island of Timor (5). And yet *Bryozoa* occur in the Upper Paleozoic in many regions, the presence and even abundance of *Bryozoa* being recorded in literature from the Upper Paleozoic of Greenland, Yugoslavia, the Himalayas, China (Sychuan), South America (Peru), etc.

The abundance of the *Bryozoa* is in some places so great as to make them the rock-forming fossils of certain horizons; of this, we may judge, for instance, from the existance of such names as *Fenestella* series, *Fenestella* shales, etc., but in the majority of cases even the genera of the *Bryozoa* found in these rocks are not listed.

And yet, in a paper on the Pensilvanian beds of Oklahoma, which are highly montonous as regards both their lithological composition and fauna, A. S. Worthin (4) expressly points to the very great stratigraphic importance of the *Bryozoa* and their relatively more restricted vertical range as compared with the *Foraminifera*, whose stratigraphic significance has been universally acknowledged.

In the Soviet Union, the study of the Paleozoic *Bryozoa* by the microscopic method was started in 1921, and at present their great stratigraphic importance has been convincingly demonstrated.

During recent years, the writer made a revision of all the Upper Carboniferous *Bryozoa* of the European part of the USSR previously studied by other authors, while the Lower Permian *Bryozoa* of the Pechora Basin (Chusovskye Gorodki) were studied by M. Shulga-Nesterenko.

The data obtained allowed the writer to make an attempt at determining the age of the oil-bearing series of the Urals on the basis of *Bryozoa*. For that purpose, by order of the State Oil Institute, Leningrad, the writer, in collaboration with B. Trizna, examined the material of drill cores from 5 wells in Ishimbaevo. These wells, situated within two domes, lie at a distance of 2.5 km from each other (wells Nos 164 and 113 in the eastern dome, and wells Nos 202, 225 and 231 in the western).

Limestones were struck in these wells at different depths from 110 to 450 m below sea level; they are overlain by the nonfossiliferous Kungur series. The maximum depth from which material was available was 750 m, the lower limit of the reef limestones being not yet reached at this depth.

The reef limestones of Ishimbaevo are homogeneous, in some places dolomitized and saturated with oil.

The authors had no data concerning the age of the reef limestones of Ishimbaevo when they started their work, neither had they any data permitting a preliminary division of the whole limestone series.

In the process of work, 600 oriented transparent sections of the *Bryozoa* were prepared. These sections permitted us to establish the presence of about 90 different forms belonging to 23 genera.

The study of these *Bryozoa* allowed us to divide the series of Ishimbaevo reef limestones into three parts characterized by different fauna.

Hexagonella ishimbaica sp. n. proved to be the typical guide form for the upper part. The main distinction of this species consists in the presence of crests on the outer surface; in the rest of its characters, it is very close to the genus *Cystodictya*, which is very common in the Paleozoic. This part of the reef is represented only in the wells of the eastern dome, where its thickness amounts to about 80 m. In the western dome, where the limestone is located 200 m lower, the upper part of the reef is absent (judging from the *Bryozoa* fauna).

The index fossil for the lower part of the section is *Ascopora nodosa* (Fischer) var. *sterlitamakensis* n. v. The genus *Ascopora* is sharply distinguished from the rest by the presence of a bunch of parallel tubules in the axial part of the zoarium. This character is readily discerned even in field conditions. In this part of the reef, representatives of *Timanodictya* (genotype *Cosciniam dichotomum* Stuck.) occur in association with *Ascopora*. *Timanodictya* is a new genus distinguished by the writer in revising the type specimens of the previously described Upper Carboniferous *Bryozoa* of the Timan. The genus *Timanodictya* is characterized by certain peculiar and readily discernible characters of the external surface. Representatives of that genus have been detected, not only in association with *Ascopora*, but

partly also somewhat higher in the section, where it occurs at the bottom of the middle part of the reef.

The middle part of the reef carries a rich and varied complex of the representatives of the genus *Fenestella*. On this part of the reef, in the eastern dome, 250 m have been penetrated in well No 113, and 350 m in well No 164. In the western dome, this part of the reef shows a thickness of but 55 m in one of the wells (No 231), while in the other (No 202) its thickness is much greater, viz., 185 m. The thickness of the lower part of the reef remains unknown, since none of the bore wells from which material was available reached the lower limit of the reef.

If, on the basis of the data obtained, an attempt be made to determine the age of the three parts of the reef referred to above, the following conclusions would seem warrantable: 1) the upper part of the reef, with *Hexagonella* may be considered to be of an undoubtedly Permian age; 2) the lower part, with *Ascopora*, of the Upper Carboniferous age. The grounds for this are as follows: the genus *Hexagonella* is characteristic of the top parts of the Lower Permian and the basal parts of the Upper Permian of Timor [the Basleo and Amarassi beds (5)]. In India this genus occurs in the Middle Productus limestone (Salt-Range), whose Permian age does not raise any doubts.

From other localities this genus had not been known, but in recent years, it was detected by M. S. Shulga-Nesterenko in the Lower Permian beds of the Pechora Basin underlying the coal-bearing series. From the undoubtedly Carboniferous deposits of the Donetz and Moscow basins the genus *Hexagonella* is unknown.

As regards the distribution of the genus *Ascopora* characterizing the lower part of the studied drill sections, it is known thus far only from the territory of the USSR, being originally described from the Miachkovo limestone of the Moscow Basin, i. e., from the top parts of the Middle Carboniferous (C_2^4).

In the same locality, this genus occurs also in higher, i. e., the Upper Carboniferous deposits (C_3^2).

In the Donetz Basin, the genus *Ascopora* is richly represented only in the Upper Carboniferous, while there are no representatives of this genus in the Lower Permian. The Upper Carboniferous of Samarskaya Luka is as rich in representatives of the genus *Ascopora* as that of the Donetz Basin.

The presence of the genus *Ascopora* in all those localities where the Upper Carboniferous is represented and its complete absence from the undoubtedly Lower Permian rocks of the Donetz Basin justifies us in asserting that this genus is a guide fossil for the Upper Carboniferous and that it does not range on to the Lower Permian.

Now, it remains only to solve the question of the age of the middle part of the reef limestones.

The beds enclosed between the *Hexagonella* beds and the *Ascopora* beds contain a very rich complex of *Fenestellidae*. This complex has many forms in common with the *Bryozoa*-reef horizons of Chusovskye Gorodki and with the Lower Permian beds of Pechora Land underlying the coal-bearing series. The Lower Permian age of the above-mentioned *Bryozoa* beds of Chusovskye Gorodki does not raise any doubts at present, and this is why the writer is inclined to refer his intermediate series to the Lower Permian. In the *Ascopora* beds, no typical Lower Permian *Bryozoa* have been met with. This fact justifies us in believing that we may draw the boundary between the Upper Carboniferous and the Lower Permian along the upper limit of distribution of the genus *Ascopora*. The question now arises: where, on the basis of the distribution of this *Bryozoa*, should the boundary between the Permian and

the Carboniferous be drawn in the thouroughly studied sections of the Upper Paleozoic of regions adjacent to the Urals (the Ufa Plateau)?

This question proposed by the Organizational Commettee of the 17th International Geological Congress as a subject for study, has not yet been taken up by anyone. Accordingly, the writer can set forth here only some preliminary data obtained from a cursory inspection of the rich material from the Ufa Plateau collected on different stratigraphic horizons by M. Tolstikhina. Among this material, the writer succeeded in detecting the above mentioned typical forms, *Hexagonella*, *Timanodictya* and *Ascopora*. The genus *Hexagonella* was detected in great abundance in the Irgino beds of the Ufa Plateau, which would seem to point beyond doubt to the Permian age of this horizon. In the next, i. e., Chernaya Rechka beds, the genus *Timanodictya* has been met with. Inasmuch as the genus *Timanodictya*, occurring in association with *Ascopora* ranges also higher in the section, the question as to the Permian or Carboniferous age of the lower parts of the Chernaya-Rechka beds will defy solution untill an exhaustive study of the whole complex of forms is carried out. The upper part of this series belongs, probably, to the Lower Permian.

The presence in the Yurezan beds of the genus *Ascopora* warrants the supposition as to the Upper Carboniferous age of these beds.

As regards a comparison of the studied Upper Paleozoic *Bryozoa* with those of other countries, the writer is compelled to state that there is almost no foreign material for comparison at all. In North America, Lower Permian *Bryozoa* are absent (or else unstudied). Some Upper Carboniferous *Bryozoa* are described from North America, but these decription are mostly too short to allow of any exact comparison.

As regards other regions, with the exception of the Permian of Timor and the Salt Range, *Bryozoa* are either not described at all or else their descriptions are too short and do not satisfy the modern rules of scientific work (the Bryozoa from the Upper Paleozoic of Australia, for instance).

The writer believes that the task before us is to study in detail all the Upper Paleozoic *Bryozoa* of the USSR and to establish the guide forms for each stratigraphic horizon.

Till recently, the Upper Paleozoic *Bryozoa* were not taken into consideration in determining the boundary between the Permian and the Carboniferous. Now, when the writer has at last had the possibility of devoting his time to their study, they proved to give very satisfactory results. And as similar work is being done with respect to other fossils from the same horizons, it will be soon possible to compare these results with those obtained from the study of other groups represented there.

Such a comparison will be of high interest to all students of *Bryozoa*. Should no contradictory facts be revealed by it, the here advanced location of the boundary between the Permian and the Carboniferous along the upper limit of distribution of the genus *Ascopora* may be considered to be correct.

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Received
18. VI. 1956.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URRS
1936. Volume III (XII), № 9 (104)

PLANT PHYSIOLOGY.

HORMONIZATION OF GRAINS

By N. G. CHOLODNJ, Member of the Ukrainian Academy

In a preceding article (1) we set forth a number of considerations and experimental data which led us to the conjecture that the basic cause for the hastening of development that is observed in the so-called yarovization of seed material is an increased intracellular concentration of the growth hormone in the growing points of the embryo just beginning to sprout.

This conjecture, naturally, led up to the question whether the normal course of the growth processes in the higher plants might be changed by artificially increasing the hormone content in the tissue of its embryo in the first stages of germination.

In the present article the results of a few preliminary experiments devised for elucidating this question are briefly set forth. The experiments were carried out chiefly on our most widely cultivated grain crops: wheat, rye, oats, barley and millet.

Two means were used of enriching the seeds of these plants with hormone («hormonization»). One consisted in soaking the dry grain for 24 hours at room temperature in a solution of heteroauxin (3-indolyl-acetic acid) of comparatively high concentration (1—2 mg of hormone in 10 cm^3 of water). It must be recognized that this concentration was high, since solutions of heteroauxin manifests a considerable physiological activity even with a content of 1—2 parts of this substance in 10^6 parts of water. The concentration of our solutions was 100 times greater.

Heteroauxin is formed in the cells of many of the lower plants (bacteria, yeast, fungi), but it is not a natural regulator of the growth and development of the higher plants. Consequently, in a number of other experiments, the endosperm of maize, which, as is well known (2), contains a considerable quantity of blastanin in all probability identical with the auxin of Kegl, was used as a source of hormone. First the embryos were excised from the maize grains by means of a scalpel, and the remaining endosperm was ground in a hand mill. The course-grained product obtained from grinding was put in smallish Petri flasks in a layer about ½ cm deep and sprinkled with tap water in such quantity as to obtain a moist (but not wet) substratum with sufficient content of air to provide for the respiration of seedlings. The maize embryos were removed in order to avoid possible absorption of blastanin by surviving portions of their tissues. The dry grains of the plants under experiment were thrust into the layer of ground and moistened endo-

sperm to approximately half their length and were left in this condition (at room temperature) for 36 to 48 hours. In the experiments with heteroauxin the control grains were placed in an equal quantity of distilled water; in the experiments with ground endosperm, the controls were placed in moistened sawdust in the same position as the grains under experiment in their substratum. When the grain swells, the growth hormone of the endosperm does not, as is well known, diffuse into the surrounding water through the seed envelope. On the other hand, it has been established that the tissues of the various organs of the developing embryo are permeable to the growth substance and can absorb it from solutions. Consequently, it would be reasonable to expect that an embryo, placed in a solution of blastanin or of β-indolyl-acetic acid would, on swelling, absorb a certain amount of these substances and would afterwards extract growth substance from its own endosperm as well, so that the general content of hormone in its tissues would thus rise considerably higher than normal.

The seeds that were placed for 24 hours in the solution of heteroauxin and those placed in distilled water had, of course, at the end of this period, swollen, but they revealed no further signs of growth. The seeds placed in sawdust had always, at the end of 36 to 48 hours, put forth shoots with more or less long roots and a noticeably grown coleoptile; seeds placed in the ground endosperm likewise usually germinated, but lagged considerably in this respect behind the control. At the end of hormonization, all the seeds were planted in earthenware pots or in wooden boxes, and their further development was in the greenhouse or in the open air, controls and experimental plants having the same conditions of growth.

Of all the preliminary experiments carried out up to the present, only two experiments with oats gave decisive results; consequently they are described in considerable detail.

Experiment 1. Twenty similar grains of oats (of the Pobeda variety) were, on April 27, freed of their husk and divided into two portions, of which one (11 grains) was «hormonized» in the ground endosperm of maize for 48 hours at 18° C in the way described above; the other (9 grains) was placed in sawdust for the same period and at the same temperature. On April 29, both sets of seeds were planted in soil in pots. The plants under experiment came up somewhat later than the controls and, at first, lagged behind them in growth. However, after a month they begun to overtake the controls, and on June 20 were almost twice as tall: the average length of stalk (from the soil to the place of junction of the last leaf) was 31.1 cm in the experimental plants and 17.3 cm in the controls. The experimental plants put forth panicles on June 21, when no signs of flowering were noticeable in the controls. After this, the difference in height grew gradually smaller and soon changed to the other side. On July 2, when the controls also flowered, they were considerably taller than the plants under experiment. The crop was harvested on July 21. The experimental plants yielded 15 grains per specimen, each weighing 0.34 grams, and 0.7 grams of straw, while the controls gave 19.5 grains, each weghing 0.36 grams, and 1.98 grams of straw. Thus, the hormonized plants flowered 12 days earlier than the controls and yielded an almost identical number of grains but considerably less straw. It must be added that during flowering and ripening of the grain of the control plants, it was unusually hot, which may have had an unfavourable influence on their development.

Experiment 2. Twenty-five grains of oats (Pobeda variety) were freed of husks and placed for 24 hours at a temperature of about 18° C in a solution of β-indolyl-acetic acid (1 mg in 10 cm^3 of water). Twenty-seven control

grains were soaked for the same period in 10 cm^3 of distilled water. After this all the grains were planted in garden soil in pots. In this case, too, there was observed a certain lagging in the growth of the plants, treated with hormone, but later on they began to outstrip the control specimens, and on June 11 the length of the principal stalk averaged 10 cm more in their case than with the controls (57.5 cm and 47.5 cm). Both the experimental and the control plants flowered at the same time, but the experimental plants flowered more profusely. The crop was harvested on July 21. On an average, a single hormonized plant yielded 18.8 grains, with an average weight of 0.56 grams, and 0.88 grams of straw; a control plant yielded 13.5 grains, each weighing 0.37 grams, and 0.48 grams of straw. Thus, in this experiment, there was no noticeable difference in the rate of development between experimental and control plants, but hormonization seems to have produced a stronger growth of the vegetative and reproductive organs, which caused a considerable increase in yield.

A favourable influence of hormonization was also observed in one experiment with wheat (*Lutescens* 063). The grains swelled in maize endosperm for 42 hours. Unfortunately, the experiment was started late (June 10), and at the time of summarizing the results, the plants had not completed their development. As in the case of the experiments with oats, the hormonized plants, at first lagged in growth, but had overtaken the controls before the end of a month. At the end of July, the plants under experiment had completed their growth and were 8 to 10 cm taller than the controls and had larger leaves.

Finally, it should be noted that other plants subjected to experimentation (as, for example, barley and millet) have not, as yet, shown a noticeable response to hormonization, except for a certain retardation in development at first. It is possible that in their case other conditions of treatment with hormone before planting are required.

The few experiments described above are only a preliminary exploration into the problem, and we are, of course, far from drawing any final conclusions. In order to reach these, more and carefully tested experimental evidence would be required, which is not at our disposal at present. Still, certain deductions of the nature of preliminary generalizations, thrust themselves upon one from the very nature of the case.

It seems very likely that the introduction into the tissues of the incipiently developing embryo of a surplus quantity of growth hormone (above that which is contained in the endosperm) affects the whole further development of the plant.

This influence may manifest itself either in a hastening of development suggestive of the phenomena observed in yarovized plants, or in an intensification of the growth of the vegetative and reproductive organs. It seems that the nature of the effect produced by hormonization depends on the concentration of hormone and on the length of time it acts on the embryo, different plants (and one and the same plant under different conditions) being differently affected by hormonization.

The chemical nature of the hormone introduced from outside is hardly of importance: together with the blastanin (auxin) of the endosperm, β-indolyl-acetic acid, as yet not found amongst the products of metabolism in the higher plants, also proves to be active.

Inasmuch as hormonization is accompanied in certain instances by an increase in yield while in others it seems to cause a hastened development and a shortening of the period of vegetation, a careful investigation of the possi-

bilities of practically applying it as a measure of agrotechnics ought to be made.

Received
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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

PLANT PHYSIOLOGY.

ON THE HORMONAL THEORY OF PLANT DEVELOPMENT

By M. CH. ČAILACHJAN

(Communicated by A. A. Richter, Member of the Academy, 7. VIII. 1936)

The development of the plant, the nature and dynamics of those internal changes which determine the whole many-sided life cycle of the plant, from the moment of the seed's awakening and the appearance of the seedling up to the formation of new seeds and the dying of the plant, is one of the most difficult puzzles of living nature. The most important critical moment in the development of the plant is its transition from vegetative growth to sexual development, from the formation of stem and leaves to the formation of flower buds and flowers. Consequently, the principal attention of investigators has been concentrated on the processes by which this transition is accomplished. To seek the internal reason for any kind of phenomenon in the life of a plant is easy when the conditions, the combination of factors of the environment by means which the phenomenon may be reproduced, are known. And the different attempts to explain the onset of flowering in plants have always been based on achievements in artificial acceleration or retardation of flowering.

Fifty years ago Sachs (1) advanced the idea of the origination in plants of special organ-forming substances, inciting the growing point to the formation of this or that organ. In the leaves there arise flower-forming substances which flow into the growing point and act upon the structural materials in such a way that they take the form of flowers.

Sachs came by this conception from numerous observations on the flowering of various plants and also on the ground of experiments he conducted with *Tropaeolum* majus. Plants grown under a screen of quinine solution in sulphuric acid and, consequently, deprived of ultra-violet rays, did not lag in growth and leaf formation behind control plants grown under an aqueous screen, but, in contrast with the latter, they gave no flowers. This led Sachs to advance the supposition of the existance of special flower-forming substances that originate in the leaves under the influence of the ultra-violet rays. The supposition that they move on to the growing points he based on experiments in which deleafed shoots at the top of the plant put forth flowers in complete darkness because of the lower leaves that were left in the light.

Sachs' idea met with many objections, both from his contemporaries and from later investigators, and had no further development.

On the basis of numerous experiments that Klebs conducted (2), his theory, according to which the flowering of plants depends on an increased concentration in the plant tissues of organic substances (sugars) and their predominance over soluble mineral and, in particular, nitrogen compounds, attained a great significance. Klebs discovered remarkable facts about controlling the development of vegetable organisms by changing their environment and these facts led him to the problem of explaining the transition from vegetative to sexual development. His experiments on the influence of light of different intensities and of different spectral compositions on the flowering of *Sempervivum* were of the greatest importance, as well as his experiments with *Sedum spectabile*, which were accompanied by chemical analyses. The theory of Klebs had a great influence on investigations in the field of the physiology of plant development, and has maintained its importance to the present day. It is quite manifestly reflected in the book of Molish (3), who quite recently wrote that «the transition of plants to the flowering stage is connected with a definite concentration of sugar, which produces a stimulation of the growing point».

When subjected to critical test, Klebs' theory has frequently failed of confirmation. Consequently, it is not surprising that in the latest works, which give a critical estimate of the present situation, it has been necessary to write that «the question of the immediate cause of the transition from the vegetative phase development to the reproductive one must be recognized as still an open one» [Knodel (4)], or, as Blackman, writing on the internal nature of photoperiodism and yarovization (5), expresses it «is in greater obscurity».

At the present time we command immeasurably more facts about the hastening and retardation of the flowering of plants than existed in the time of Sachs and Klebs. Garner and Allard's theory of photoperiodism (6) is one of the most remarkable discoveries and has completely changed our conception of the relation of plant to light and of the formative influence of the energy of the sun's rays. It is natural that just this photoperiodic reaction of plants (the reaction to change of length of daylight) served as the basis for new deductions concerning the physiological nature of plant development.

Study of the mechanism of the photoperiodic reaction, the results of which we have hitherto published (7), has shown that «the processes caused by changes in the duration of daylight illumination and which lead to sexual ripening of plants (flowering and the formation of fruits) take place in the leaf tissues». The influence of these processes then is transferred from the leaves to the growing points of shoots, which under this influence, reach sexual maturity or else continue vegetative growth. The transfer of this influence may be accomplished only through presence of material carriers capable of being transported from the leaves along the stem and of controlling the formation of shoots in the one or another direction. Are these material carriers the same substances which form the structural materials (assimilates) or do there pass from leaves to growing point, along with these structural materials, some specific substances with a regulatory function?

In order to answer this question, it was necessary to prove that the processes of development occur independently of the processes of growth and show the specificity of those qualitative changes which determine the onset of flowering in plants. The independency and specificity of the processes of development are clearly marked in plants hastening their development under the short day. Numerous experiments that we have conducted with chrysan-

themums, perilla, millet, hemp, soy, and the Kuban sunflower have invariably shown that the growth of stems and leaves and the accumulation of dry matter go on the more intensively the longer is the duration of daylight, while flowering begins considerably sooner with an artificially shortened (10 hours) day. When simultaneously sown there results, in the long day, strongly vegetating plants, with a great quantity of nutritive structural materials, whereas, in the short day, there result smallish plants with a considerably smaller assimilating surface and early forming flowers. In these plants, flowering in no wise depends on accumulation of nutritive substances.

But quite another combination of the processes of growth and development is obtained in experiments with wheat, barley, flax, vetches and mustard. In this case, too, the intensity of growth and the accumulation of dry matter is higher in the long day, and together with that, flowering also begins more quickly. The picture of growth and development of these plants within a definite period, when flowers appear on the larger plants of the long day possessing a greater leaf surface, whereas on the smaller plants of the short day there are no flowers, would seem to confirm the statement of Gebel and Klebs to the effect that flowering depends on the quantity and quality of nutritive substances. But it is not really so. In our experiments with mustard *Sinapis alba* it was shown that after the plants have matured and begin to dry up in the long day, growth continues slowly and uninterruptedly in the short 10 hour's day. In the course of time, the plants of the short day grow more vigorous as the plants of the long day (at the time of their flowering), but do not form flowers. Hence, it is apparent that in this group of plants, also, we have only a coincidence of growth and development, whereas the internal changes determining them are not identical.

Consequently, the processes leading up to the sexual development of plants are not determined by the processes of their growth and nutrition, but are specific in their nature.

Returning now to the question of the nature of the material transferrers of the influence induced by light from the leaves to the growing point, it has to be recognized that these are not structural materials (nutritive substances) but are specific substances with a regulatory function.

Just as, in the growth processes, the regulatory function is fulfilled by the hormone of growth, so, in the processes of development, a hormone of flowering, or a flower hormone fulfils this function. The flowering of plants is beginning as the result of the formation in the leaves of a sufficient quantity of the flower hormone and of its transferring into the growing points.

The maximum production of this hormone occurs under those conditions of change of day and night, in combination with other factors of environment, to which the development of this or another kind of plant has become adapted during the process of its evolution. When there is a deviation from these conditions, the production of the flower hormone decreases and the flowering of the plant is retarded; when there are great deviations, the accumulation of the hormone is so slight that the plants do not form flowers at all and grow uninterruptedly, giving new vegetative shoots and leaves all the while.

Timiryazev [8] affirmed that the leaf is the only natural laboratory in which is produced organic substance in both the kingdoms of nature and in

which there is laid up a supply of solar energy. In this same laboratory, the leaf, under the influence of solar radiant energy, substances are synthetized which regulate the development of the plant from seed to seed.

The usual movement of the flower hormones is from the leaves to the shoots rising from the axils. Our foregoing experiments have shown that such relations as these may be artificially set up between lower leaves and upper, deleafed shoots ([7]). If the whole plant is in optimal conditions for the production of the flower hormone, then all the growing ponts are supplied with it, and the plant passes into the stage of «ripeness to flower».

We made an attempt to disturb the usual condition of the whole system of the movement of flower hormones within the plant. For this purpose, experiments were carried out on the large-flowered chrysanthemum *Chrysanthemum indicum;* the variety taken was the Schräder, which forms flowers quickly in the short day. The leaves on the principal stalk of each plant were counted, and all the even-numbered leaf blades (without shoots) received 10 hours of light per day (from 6 o'clock in the evening till 8 in the morning they were covered with black caps), while all the odd-numbered leaves were left in the natural (long) daylight. Owing to the shortening of the day for half the leaf surface in this way, flower buds began to appear on the shoots of these plants. The buds appeared first of all in the axils of those leaves whose blades were subjected to the short day. However, in the axillary shoots of leaves whose blades received the full normal daylight, bud formation also began, which was not the case in plants which in their entirety received the full normal daylight. With the beginning of flowering, the picture became quite distinct. Flowers opened only in the axillary shoots of the covered leaves, as is shown in Fig. 1 (photo taken October 14, 1935). Not a single flower had appeared on the axillary shoots of the control leaves at the time of taking the photo.

Fig. 1.

Together with that, on one of the plants under experiment, there appeared yet another peculiarity: on an underground branch from the stalk, there formed a shoot with two tiny leaves, which immediately began to form flower buds. Ordinarily a shoot from the base of the principal stalk of the chrysanthemum never gives flower buds, and there were none such in the case of the plants that did not receive an artificially shortened day. In Fig. 2 (photo taken October 4, 1935) is shown this budding shoot on the underground branch from the main stalk of the plant.

These facts show that when there are leaves on the plant that, under the influence of an artificially altered day length, produce the flower hormone— «ripe to flower» leaves —and leaves not possessing «ripeness to flower», the basic mass of the flower hormone passes into the shoots rising from the axils

of the «ripe to flower» leaves; but a certain part of the hormones are distributed throughout the whole plant and move to the growing zones. This movement of flower hormones takes place both upward (in an acropetal direction) and downward (in a basipetal direction).

In the light of what has been set forth above concerning the hormonal nature of the development of plants, such complicated phenomena as the

Fig. 2.

photoperiodical after-effect (induction) and reversibility of reaction become understandable.

Photoperiodical induction is the result of the action of the flower hormone produced in the leaves during a short exposure of the plant to light conditions which hasten flowering. The growing points, when supplied with a sufficient quantity of the hormone, quickly form flower buds and flowers, notwithstanding that the plants are now placed in conditions that do not favour the production of the hormone in the leaves. In plants having a high capacity of regenerating new growing points, as, for example, hemp and perilla, these new formed growing points receive an insufficient quantity of the flower hormone, since a large part of it has already gone into the earlier formed shoots. Consequently, the shoot, on beginning to flower, passes again to vegetative growth—that is, the phenomenon of reversibility of reaction occurs.

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Received
7. VIII. 1936.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1936. Volume III (XII), № 9 (104)

ZOOLOGY

ON THE FAUNAL FEATURES OF THE NORTHWEST TIAN SHAN

By L. M. ŠULPIN

(Communicated by S. A. Zernov, Member of the Academy, 4. V. 1936)

The works of N. A. Severtzow (1) and M. A. Menzbir (2) on the ornithology of Tian Shan and Pamir-Alai have outlined the chief zoo-geographical groups (faunulae) composing this fauna. Among these, the group of Himalayan and boreal forms, which display a combination of faunal elements very abruptly different and far apart in origin, has attracted the greatest interest. The degree to which these forms have intermixed proved to be the most important feature characterizing the zoo-geographical position of any region of this mountainous country. However, our knowledge of the distribution of these mountain elements is still quite insufficient, and often their routes of invasion and the relations of their distribution with definite complexes of environment are not yet plain.

In 1933, 1934 and 1935, I was able to carry out a faunal investigation of the North-west Tian Shan in the region of the Aksu-Dzheboglinsk reservation in the Kazakh Autonomous Soviet Socialist Republic, partly under orders from the Kazakhstan Branch of the Academy of Sciences, partly under the auspices of the Laboratory of the Ecology of Vertebrates of the Leningrad University and of the Peterhoff Biological Institute.

During this work, a number of new facts regarding the distribution of vertebrates in the North-West Tian Shan were revealed and certain regularities in their occurrence were noted. A number of Himalayan forms were found to penetrate considerably further than had hitherto been known. Thus, *Parus rufonuchalis rufonuchalis* Blyth. was found nesting in the ravines of the Bugulutur, Kshi and Ulkun Aksu rivers between the ranges of the Talas Alatau. *Certhia himalayara taeniura* Sewerz. was not infrequently found wintering in the canyon of the Aksu River in the region of the foothill steppes of the North-West Tian Shan. *Emberiza stewarti* Blyth., *Myophonus caeruleus turkestanikus* Zar. and *Oriolus oriolus kundoo* Sykes, known for the Kara-tau and partly in the more eastern parts of the Tian Shan, were found nesting high in the mountains, up to 2400—2500 metres.

The distribution of a number of forms endemic to the Western Tian Shan and Pamir-Alai was also traced considerably farther to the North. *Strix aluco härmsi* Zar. was found in the valley of the Baldaberek and Dzhebogli Rivers in the northern spurs of Talas Alatau. *Cyanistes flavipectus* Severz., common during the nesting period in the ravines of the Aksu and Dzhebogli

rivers and wintering further down in the valleys of Arys and Chimkent, has a wider distribution. This find makes it probably correct to refer the blue titmouse observed by N. A. Severtzov (3) on the Talas River directly to this species and to establish a boundary between this species and *Cyanistes scyanu tianschanicus* (Menzb.) in the region of Kirghiz Alatau (Alexandrovsk Range).

The Western Tian Shan *Chloris chloris turkestanica* Zar. was mostly confined to the zone of foothill steppes, but in some places was discovered nesting high in the mountains, up to 2400 metres in the basin of the Bala Baldaberek.

As regards the mammals, mention should be made of the find of *Rattus turkestanicus* Sat. in the canyon of the Aksu, which is the most northerly point in the range of this species in the mountains of Middle Asia, the occurrence of *Marmota menzbieri* Kaschk. in the western parts of the Talas Alatau (on its northern slopes, up to the source of the Sairam), and the finding by P. N. Meklenburtsev of *Phaimys carruthersi* Thos. in the alpine zone of Aksu Range in large colonies.

The penetration of all these forms, which are southern with regard to the region studied, by various routes is interesting. Part of these forms are connected with juniper trees (*Parus r. rufonuchalis* Blyth., *Certhia himalayana taeniura* Sev., *Strix aluco härmsi* Zar.), and their occurrence ends where the tall juniper trees (chiefly *Juniperus semiglobosa* and *polycarpos*) cease to occur on the crags. The distribution of other forms is influenced by the presence of crab trees in the mountains (*Cyanistes flavipectus* Sev. and *Rattus turkestanicus* Sat.). Finally, certain forms are connected with the shrubby vegetation on the rocky slopes (*Emberiza stewarti* Blyth.), with the shady ravines of rivers (*Myophonus caeruleus turkestanicus* Zar.) and with the alpine meadows (*Marmota menzbieri* Kaschk., *Phaiomys carruthersi* Thom).

A survey of the populations of the habitats mentioned shows that not one of them is characterized by a fauna homogeneous by its origin. It follows then that these forms penetrate independently of one another within their specific environments. This also shows that in the region studied the more southerly faunal elements of the Western Tian Shan disappear.

Typical boreal forms were not found nesting in the North-West Tian Shan, a fact that should be correlated with the absence here of fir forests, found in other parts of the Western Tian Shan and always inhabited by a corresponding fauna (4). A number of forms, chiefly of northern origin, do reach into the district; however, they rather frequently manifest ecological peculiarities. Thus, *Anthus trivialis* (in spec.), usually a forest dweller, here is found breeding in the subalpine meadows. *Musicapa striata Neumanni* Poche is strictly confined here to mountain riparian forests, but does not occur among the crab and juniper forests. *Sylvia nisoria merzbacheri* Schalow manifests great annual fluctuations in numbers. *Oenanthe o. oenanthe* L. is extremely sporadic and nests mostly ne r thawing snow. The breeding of *Cyanosylvia svecica tianschanicus* Tugar, is also extremely sporadic. *Erythrina erythrina* subsp. breeds only in the mountains in forest-scrubzone of treelike shrubs and the subalpine meadows.

The Mediterranean element is the most abundant in the fauna. Under this head are included both those forms that are concentrated in the Mediterranean region proper and those that inhabit nearly the whole mountainous and desert area of Central Asia. The species of this group compose the greater part of the populations of rocky and shrubby slopes and, partly, the alpine zone. Among the different species found may be mentioned *Rhodopechys sanguinea sanguinea* (Gould), some years quite numerous in almost all zones of the

mountains and nesting there; *Petronia petronia intermedia* Hart. which penetrates far into the mountains and nests both in the crags and in the hollows of juniper trees; *Sylvia hortensis crassirostris* Cretzschm., quite frequently nesting in the thickets of shrubby and treelike juniper of the whole district, *Sylvia curruca affinis* Blyth. (*althaea* Hume) nesting in the valley of the Dzhebogli and Aksu Rivers, *Irania gutturalis* (Guérin), frequently nesting in the lower belts of the mountains, and *Hieraaëtus pennatus* (Gm.) nesting in the mountain ravines. Several of these forms are, at this latitude, near to the eastern limits of their range. The abundance of Mediterranean forms strongly emphasizes the fact that the region studied belongs, as a whole, to the Western Tian Shan district (5).

The most intimately related with a definite habitat—the creeping subalpine junipers and alpine meadows—is the group of Central Asiatic forms (the faunula embracing the mountain system situated between Altai-Sayan and the Himalayas). The range of the species of this group extends along the mountain chains and includes, in this region, the Aksu chain up to the upper course of the Talda Bulak river, the Bugulutur, Maidan-Tal and Ugamski ranges. Among interesting finds mention should be made of *Erythrina rhodochlamys obscurata* Korowin, found throughout the whole area of the habitat mentioned, *Leucosticte brandti brandti* Bp., nesting in the upper courses of the Dzhebogli and Kshi Aksu Rivers, *Phylloscopus inornatus humei* Brooks, found nesting along the upper course of the Dzhebogli River *Herbivocula griseolus* (Blyth.), found along the whole Aksu Range, *Calliope pectoralis bailloni* (Sew.), nesting along the upper course of the Dzhebogli, Kshi Aksu and in some places on the Aksu Range.

A comparison of the composition of these Central Asiatic forms with their composition in the Eastern Tian Shan shows a fauna considerably impoverished with respect to this element. For some reason not yet understood, for example, *Leptopoecile sophiae sophiae* Sew. and *Troglodytes troglodytes tianshanicus* Sharpe are not found breeding here.

From the analysis carried out it appears that, as regards the general composition of its fauna the Talas Alatau is a typical Western Tian Shan region with a predominance of Mediterranean forms. The northern position of the region leads to the disappearance of Himalayan elements, only some of which penetrate there. However, boreal forms proper are absent here.

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Received
4. V. 1936.

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